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The Rivers of the Punjab.

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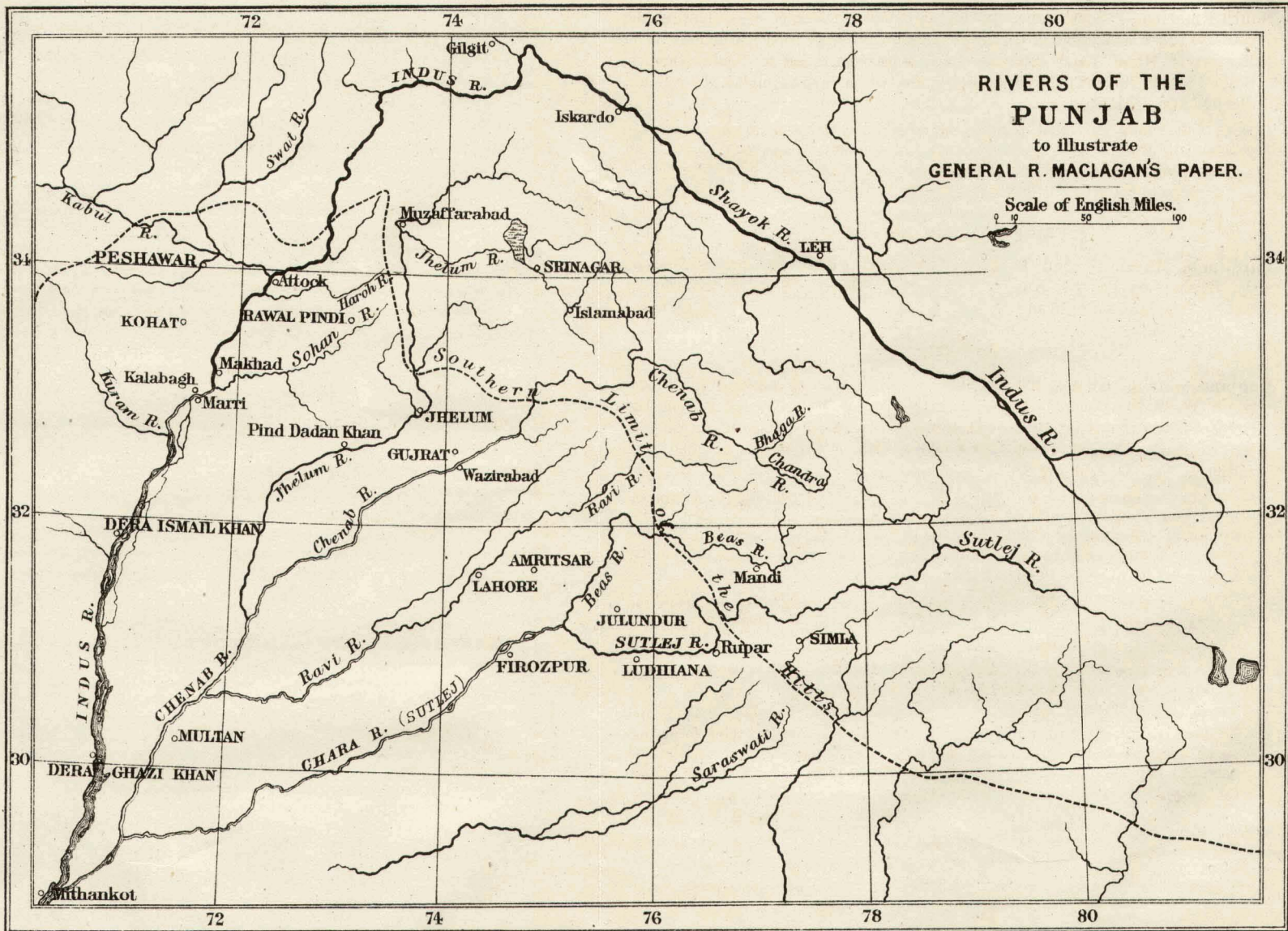
Map, p. 776.

THE Punjab receives its name from the rivers which give to the country its distinctive geographical character. The name, as is well known, means "five waters." And these five waters are the five great rivers which, united, flow into the Indus about 500 miles above its mouth. They are the Jhelum, Chenab, Ravi, Beás, and Sutlej.

In early times the country was called the land of the "seven rivers," this number, seven, including, in addition to the five just named, the Indus itself on the one side, and the Saraswati on the other.

The modern British province which we call Punjab, the country marked off for administrative purposes as the charge of the Punjab government, is not thus bounded by the distinct lines of one river system. Beyond the Indus, on the west, it reaches to the line of hills that runs for a long distance nearly parallel to the river. And beyond the Sutlej, on the other side, it includes a large tract of plain country as far as the Jumna, a river which has different geographical relations.

The ancient seven-river-land had very distinct river boundaries as then understood, and as described in certain ancient writings. The eastern boundary, the Saraswati, has a somewhat obscure history, and presents an interesting geographical problem. The Indus and the other five rivers take their rise in the snows of lofty mountains, and are great streams at all times, being fed from unfailing sources. The Saraswati, on the other hand, rises in the low outer hills, and, receiving its water from the periodical rains only, and the springs which they supply, it is nearly dry for great part of the year, and at flood seasons is quickly filled with a great body of water, which pours violently down and runs rapidly off. It has all disappeared before it can reach the Sutlej or the Indus. But in the ancient writings referred to, it is described as a mighty river like the others.



Let me mention briefly what these ancient writings are, and what they have to say to the geography of this part of India. The earliest knowledge we have of this country and its inhabitants relates to the immigration of a people of the Aryan race from the north. These are the ancestors of the Hindus. This immigration took place, as well as can be determined, about 1500 B.C. (a little before the exodus of the Israelites from Egypt). For a length of time this Aryan people occupied the seven-river-land, as they called it, before they began to advance further into India. Certain of their sacred books, written during this time, contain descriptions of some geographical features of the country, particularly in the shape of hymns addressed to the rivers. Though the information thus furnished cannot be credited with any scientific accuracy, it is not altogether without value in relation to the geography of to-day. In these Vedic poems the Saraswati is addressed as a mighty stream of the same kind as the other rivers, and in terms implying great size and importance. It is called the "most beautiful of the seven sisters"; "first of rivers, rich and pure, flowing down to the sea*"; "the Saraswati our protection," evidently looked upon as a great river which was a safe frontier. The name, which means "having running water," seems to mark it as a constant as well as powerful stream. It is applied as an epithet to the Indus and other great rivers. What is the change that has taken place?

The tract of country through which the Saraswati and other similar periodical rivers near it and connected with it (Gaggar, Markanda, Chitang, and others) take their course, was formerly more cultivated, peopled, and wooded, than it is now. There are remains of many villages and towns, but little of the old forests. Clearance of forest has no doubt a good deal to do with the altered condition of the country and its rivers. It has been the practice also, when water was scarce, to throw dams across the channels to hold up all that could be had. Then, lower down, where water seldom came, the wind and sand filled up the river beds, as happens in many places at the present day. If a great change in the character of the Saraswati can be thus accounted for, still, rising so near the plains, it can scarcely ever have been a continuous stream of great volume, worthy of being described in the terms applied to it in those old days.

Now in later writings, the date of which is about the sixth century B.C., this famous river is said to sink into the earth and to pass underground to join the Ganges and the Jumna at their confluence. It had ceased, according to this idea, to be one of the seven rivers. It had no connection with the other six. The people had now crossed their boundary river and advanced into India. They had become acquainted with the Ganges and the Jumna. These were now their sacred streams, and their confluence, Prág, now Allahabad, was a place of special virtue.

* The word is applied to large rivers as well as to the sea.

Had they by this time come to know the Saraswati better, to find out that it was not the kind of river it was thought to be when it was less perfectly known and had not been crossed, or perhaps when it had only been seen in flood? And then had they come to think that its ancient credit would be best upheld by taking it underground to Prág (which now, as the meeting-place of three sacred streams, receives the epithet Tribéni)?

Was there then, ever, in the place of these dry channels, a river such as the Saraswati is described to have been? One answer to this question has been given in the supposition that the Sutlej, which makes a somewhat abrupt turn westward near Rugar, soon after issuing from the hills, once took the more direct course south-west, and that it was the Saraswati. It is not impossible that the Sutlej may once have followed that line, but the supposition is not well supported. It has been said that the Sutlej is not mentioned by the historians of Alexander, who speak of the other four great rivers emptying themselves into the Indus, and it is inferred that in his time it cannot have been where it is now. But, as was long ago observed by Lassen,* Alexander went no further than the Beás, and, to the Greek historians and geographers, this river, which was the terminus of his expedition, was the furthest thing in the country they had to mention. To which it might be added that the Saraswati also is not mentioned, but this does not imply that it was not there. Also that the seven rivers of the old Indian writings include both the Sutlej and the Saraswati? And that it was about three centuries before Alexander's time that the Saraswati had lost itself in the sand.

A change there had been before then, but a change, we may reasonably suppose, not so much in the river itself as in the people's knowledge of it. After all, the Vedic hymns which use these high-flown descriptions, while containing many useful facts, are not books of history or science but of poetry and nature-worship. Something may be attributed to the Oriental love for expressing completeness by the number seven, and to a natural desire to find something worthy of special mark in the seventh river, which they looked upon as the boundary of the land they claimed for the Arya or noble race.

We must not conclude that the interesting question can be finally disposed of in this way, but there seems to be enough in causes that are apparent, and changed conditions which are known, to explain the state of things that now exists.

The river Sutlej, whether flowing as at present or by the other line, is the natural eastern boundary of a great tract of hill and plain country enclosed between this river and the Indus. These rivers have their sources very near to each other, on the sides of the mountain Kailás (lat. 31° 4', long. 81° 15' E.). The Indus main line rises on the north

* 'Pentapotamia Indica,' 5.

side of the mountain at a height of about 18,000 feet. The Sutlej on the south side issues from the lake Ráwan Rad (connected with the Manas Saráwar lake), at a height of about 15,200 feet. The Gár branch of the Indus rises on the south side of the mountain, close to one of the sources of the Sutlej.

The courses of the Indus and of the Sutlej have a general similarity, taking first a north-west and then a south-west direction, the larger river making a wider sweep, which separates it about 350 miles in direct distance at the widest part from the Sutlej, that is, from the sharp turn of the Indus near Gilgit (lat. $35^{\circ} 50'$, long. $74^{\circ} 45'$) to the bend of the Sutlej near Rugar (lat. $30^{\circ} 58'$, long. $76^{\circ} 35'$). And they unite in the south of the Punjab, above Mittan Kót (lat. $28^{\circ} 58'$, long. $70^{\circ} 23'$), the Indus having run about 1350 miles, and the Sutlej 950 miles. Within this ring are situated all the other Punjab rivers, from source to confluence, with all their tributaries and all their drainage ground.

From their rise to their final exit from the hills these rivers have all a character generally similar. Now they are foaming torrents, dashing down narrow rocky channels with wild force, then rushing on with current less riotous if not less rapid, and at length, with slackened speed and all the gathered volume of many such like streams, sweeping down, broad and deep, into the plains. But this is not an unvaried plan. The Indus, for instance, as it passes through Ládák, flows for a long distance in an open valley at a height of 11,000 feet, over a sandy bed, with gentle and winding current, a smooth surface, and divided stream. The Sutlej too passes smoothly through some bits of comparatively open country in its journey through the hills. But the most notable and well-known piece of slack running of a great river through high level land among the hills is the upper part of the Jhelum in Kashmir. The river rises near Vir-nág at the south-east end of the valley and flows north-west through the middle of a wide plain. It receives several tributaries, some of equal size to the main river. It passes the capital, Srinagar, about 70 miles from the source, and 25 miles lower down it spreads over a broad depression in the plain and forms the Wular Lake. Leaving this lake near the town of Só-púr (which suffered so severely in the late earthquakes) it runs south-west 18 miles to the gorge at Baramúla. This is its course through the lovely valley of Kashmir, a little over 5000 feet above the sea, where it is a sluggish but beautiful river, with a large amount of lazy and luxurious boat traffic. It is a single channel, but some of the tributaries have streams much divided. From Islámábád, where several of these streams join, down to Srinagar, 40 miles, the fall is four feet per mile. Then to the Wular Lake and out of it to Baramúla, 43 miles, only about $2\frac{1}{2}$ feet per mile. But now comes a change. From this place, Baramúla, the only river exit from the valley of Kashmir, the river which has been creeping along so quietly now dashes down

between precipitous rocky banks with a fall of 35 feet per mile for 75 miles, to the town of Muzaffarábád. And here joined by the Kishanganga (or, we might say, joining it, as the Jhelum makes a very sharp turn to the south, adopting the course of its tributary), it runs on with a fall of 21 feet a mile to its entrance on the plains of the Punjab. Here again it begins to be a boat-bearing stream. Its whole descent, from the source to the plains, is thus made suddenly, in a short distance in the middle of its course.

The earliest of a series of four metrical histories of Kashmir, in Sanscrit,* states that the valley was formerly a lake, which was drained by a powerful sage cutting the gap at Baramúla, by which the Jhelum now escapes. In the actual physical condition of the country we can see some ground for the tradition. Bernier, referring to this story, which he was told in Kashmir in 1664, suggests that the gorge at Baramúla was rent by earthquakes, which, as he says, and we have reason to know, are frequent in that part of the country. M. Troyer, the translator of the Sanscrit history just referred to, thinks it was the work of man, taking advantage of the facilities presented by the narrow neck of land which closed in the great lake at that end. It has otherwise been supposed that the river of old had a free flow, with pretty uniform slope from the source to the junction of the Kishanganga, that it was blocked below Baramúla by landslips, and that when the barrier, after many ages, partially burst, the lake, which had been held up, subsided, and the river made its way down by a rapid fall to its old channel.

The other rivers have their general fall in the more usual order, the high slope at the head decreasing in successive portions to the low flat run of the Delta. The Indus has an average fall of 24 feet per mile from the source to Iskardo, 600 miles; 17 feet per mile to Attock, 440 miles; from Attock to Kalabagh, 110 miles, 50 inches per mile; Kalabagh to Mittan Kót, 370 miles, 12 inches a mile; and 470 miles Mittan Kót to the sea, 6 inches a mile. The Chenab has two chief upper streams, the Chandra and the Bhaga, and the river below their junction is called by their joint name, the Chandra-Bhaga. They both rise on the Bara Lacha range at a height of about 16,500 feet. The Chandra in its 115 miles down to the junction at Tandi, which is 7500 feet above the sea, falls upwards of 70 feet per mile; the Bhaga has little more than half the length with twice the fall. From Tandi to Kishtwar, 115 miles, the river falls at the rate of 34 feet per mile, and thence 180 miles to Aknúr at the foot of the hills, 26 feet per mile. The Ravi, the smallest of the five rivers, has its source at a height of 16,000 feet and a rapid descent at the rate of 115 feet per mile, in its hill course of 130 miles. The Beás rises in the Rotang Pass, at the head of the Kulu valley, close to the source of the Ravi, but at a lower height. To Lárji,

* *Raja Tarangani*, the first of the series being written by Kalhana, about the middle of the 12th century.

75 miles, its fall is 125 feet per mile, and in the next 25 miles to **Mandi** rapidly goes down to 40 feet a mile. Then for 150 miles it falls at 11 feet per mile. This river is noted for the beauty of its scenery in the hill part of its course. Of all the Punjab rivers the Sutlej has the most equable slope in its way down to the plains. At 240 miles from the lakes at its head (the place where it is crossed by a large timber bridge a few miles above Shipki) its height above the sea is 8400 feet, the descent per mile to this place being 32 feet, and it has the same average fall in the next 300 miles to Rupar.

In their passage across the plains the rivers have a character generally similar, with some distinctions. The slope is small and decreases as they descend towards the sea. They do not keep to one course or to one form in any part of their course. The changes are the results of two kinds of action, destructive and constructive. They cut away their banks and build others. They have two ways of destroying their banks; in the flood season by direct force of the stream at a high level, and softening of soil submerged, and in the low season by quiet undercutting at the water-level, which brings down enormous masses of high bank that fall forward one after another into the stream with loud and repeated roar. The soil thus carried away is part laid down on shelving banks on the other side, part in the bed, forming shoals and shifting islands; part settling down across the mouths of branch channels, closes them up and cuts off their supply of water, till another turn of events lets water into them again; and part is swept down the stream to the delta and the sea. All this is familiar to us on rivers in all countries flowing through such plains. There are long stretches of river bank on the Mississippi which very exactly resemble those of the Indus, and which the river treats in exactly the same manner.

The changes caused by the cutting of banks and formation of new ones are often of large amount and importance. No one of these rivers is at any time exactly where it was the year before. The town of Mittan Kót, just below the common confluence of all the rivers, has twice (according to the ordinary way of speaking of it) been carried away. But this does not describe exactly what happens. For though, no doubt, many buildings and much property on the banks of all these rivers are annually swept into the river, this is seldom done without warning. And when the people see it is inevitable, they try to move in time to some place farther back, or some other part of the river-side that seems more secure. When surveying in Upper Sind, and engaged in recovering positions I had mapped the year before, I missed a village that was in my books, and on inquiry it was pointed out to me on the other side of the river. The people had got unmistakable notice to quit, and they flitted over the water. The river had cut in more than half a mile from its bank of the year before.

The Ravi, which is the smallest of the five rivers, has the most

winding course in the plains and great tendency to change. Bernier, when at Lahore in the end of 1663, preparing to go to Kashmir with the Emperor Aurangzib, writes that the city was built on one of the five rivers, which may be compared in size to the Loire, and which he says was equally in need of a dyke to check the mischief it does in its frequent changes of bed. He said the king's palace was then no longer on the river bank as it used to be, the stream having receded a quarter of a league, to the great inconvenience of the people. (I had a river-gauge set up one year below the palace, to which side a part of the stream had returned. I believe it has never been there again since.) The emperor to whose suite Bernier was attached built a long masonry facing to the river bank on this side, and now it would appear it had begun to threaten the other. For some time before the British occupation of the Punjab, the river had been encroaching on the opposite bank and was cutting away a corner of the enclosure of the Emperor Jahangir's tomb at Shahdara. To prevent its going further and endangering the beautiful tomb itself (erected by the emperor's widow, 1630) the river was encouraged to lay down silt on that side and make a new bank. This it did, and it now runs fairly away, with a good breadth of new land between the stream and the place it had damaged. The same thing has had to be done elsewhere on this river. On two occasions our military station Dera Ismail Khan has been threatened by the Indus, and protected by river works which turned the main stream into channels that took it to a safe distance. These rivers have not only the habit of changing from right to left within a great width of general course, but also, like rivers elsewhere, occasionally take up a new line altogether. Considerable lengths of an old bed of the Ravi are to be seen some miles to the west of its present course. The Chenab, the Beás, and the Sutlej also have left old beds with which they have no connection now. Parallel to the lower Indus is a long piece of river channel, in which part of the stream is believed at one time to have run.

In a straight run, where these rivers do not tear their banks or change their course, they have still the power of making other alterations by deep plunging of their bed. When the first railway bridge across the Sutlej, between Ludiana and Fitor, was built, the pier foundations were carried down to a depth of 70 feet. A heavy flood scooped out the bed under one of these piers, bringing down with it two spans of the fine bridge. There seems to be a direct downward action of a strong current meeting a vertical resistance of this kind, which cuts the bed more deeply than a free unobstructed stream. Yet the Indus 20 miles below Attock, with its continuous high velocity and great volume, has cut a central trough which is believed to be about 180 feet in depth. At Attock, which the river approaches in a wide and divided channel with low velocity, the depth is only 22 feet at low water. This favoured the project of a tunnel under the Indus. The

small trial gallery was driven the whole way, opening communication, in 1863, from side to side under the river, with shafts on either side. The projected road tunnel was not carried out, and a railway bridge now spans the Indus at this place.

A bridge over such a river, at such a place, is much concerned with the amount of rise of the river in floods. The Indus channel which is open and divided before reaching Attock, here narrows between rocky banks, and the river therefore rises to a great height. A height of 50 feet in flood season above the lowest level at other times is common, with a velocity of 13 miles an hour. At M^ari, 90 miles lower down, the highest rise is only 17 feet above low-water level. In a flood of a remarkable kind in 1858 the rise of the river at Attock was 80 feet; and in the flood of a similar kind in 1841, the rise is believed, from the information obtained (the Punjab was not ours then), to have reached a height of no less than 92 feet. The other Punjab rivers have wide open channels in the plains, and while their volume is largely increased in the flood season their rise is told in more moderate figures, the maximum between 10 and 15 feet.

The ordinary rises of these rivers are due first to the melting of the snows and then to the periodical rains. The rise from melting of the snows, which begins in March, is slow and regular, but not uniform. Snow-melting on the high hills is checked by frost during the night and early morning, and goes on again during the day. The fluctuation in rise, which sensibly affects the rivers in the upper part of their course, is little perceived when they come out, broad rivers, into the plains. The temperature of the Indus water, in the cold weather of the plains, has been found to be 5° below that of the air (64° and 69°, February). In the beginning of the hot weather, when the air is warmer and the river is bringing down snow-water, the difference is 14° (87° and 101°, June). At greater depths the difference is still more, a fact of which practical advantage is commonly taken by the English residents in the fort of Attock, by letting down to the bottom for some hours anything which it is desired to cool.

The greater ordinary rises of the rivers are from rain, that is, rainfall on the hills from which the rivers come. All of these rivers and their feeders have their source within the broad tract of grand hill country which stands between the great lowlands of North India and the wide outspread highlands of Tibet. This vast mountain region, bearing the common name Himalaya, includes a number of lofty ranges, in a general way parallel, and stretching north-west and south-east. The main annual rainfall in North India is that swept up from the surface of the Indian Ocean by the south-west winds of the summer monsoon. The first of the parallel ranges of mountains that is high enough to catch, and cold enough to condense, the water-laden air-stream, receives copious rain on its seaward side, while the other side of the mountain wall gets little

or none. The same thing is repeated on ranges beyond. It is a curious and striking thing to see. Crossing the hills into the valley of the Sutlej on one occasion in the height of the monsoon, I went up the south side through soaking rain and rank vegetation to the very pass, and on descending the ice and bare slopes on the other side all was dry. No rain for weeks, till, as I came back across another range on the north side of the Sutlej from the valley of the Spiti, this experience was reversed, and crossing from the dry and bare north side, the descent on the other was again in heavy rain amid luxuriant greenness and the roar of dashing streams. How quickly the little mountain torrents uniting form a river can be seen on those magnificent hills in time of summer rain. The same thing is to be seen on a smaller scale in the western lake countries of Scotland and England. There are places in Cumberland where ten times as much rain falls on the windward side of a hill as on the other. The arrest of some of the monsoon clouds in the Himalaya goes on at all the lofty ranges that stretch along the great belt of mountains. Thus the quantity of rain that is carried by the wind becomes less towards the further or Tibetan side, and the monsoon wind arrives there vapourless. So also the annual snowfall is less towards that side, and snow is permanent down to a lower level on the ranges near the southern than on the ranges near the northern margin of this great mountain land. And again, just as the first of the high ranges on the south side of the chain shelter the valleys next beyond them from the moisture that comes from the south, so the ranges nearest the other side of the chain screen the country behind them from the dry heat of the high land on the north.

The main stream of the Indus, then, comes from a drier part of this chain of mountains than all the other Punjab rivers. But this has little effect on its volume except on the upper part, for besides its numerous affluents direct from the great glaciers, it receives a large amount of drainage from the hills south of its main stream, more favoured with abundance of rain. It drains an area estimated at 372,000 square miles. Even at its lowest, in winter, it is 500 feet wide at Iskardo, and nine or 10 feet deep. The upper Jhelum (called by its old name the Behat (Vitasta) in Kashmir) has that valley for its definite drainage area, but receives important tributaries, the chief of which is the Kishanganga. The Chandra and the Bhaga, which united form the Chenab, are both great streams, receiving large supplies of water from both snow and rain on the south face of the Bára Lácha range. The valley of the Ravi, in its short course among the hills, is partly deprived of monsoon rain by the hills which on their south side—the side of the Kangra valley—send down an exceptionally large amount to the Beás. The average annual rainfall at Dharmsala, overlooking the Kangra valley, is 140 inches. The Sutlej has a long course through dry country, but a large amount of drainage from the spurs of the Kailás range. This whole wide area

of mountain range, the birth-place of the Punjab rivers, is full of varied interest to the geographer, and to others besides.*

The *local* rain in the country through which these rivers flow in the plains affects their rise in comparatively small degree, though it of course adds something to their volume, and may cause very serious flooding of level land which drains slowly. Each of the Punjab rivers after leaving the hills crosses a tract of steadily decreasing rainfall on its way towards the sea. The Indus and the Jhelum enter on the plains in country that has 36 inches of average annual rain. On the Chenab where it leaves the hills there fall 48 inches in the year. The Ravi and the Beás get 34, the Sutlej a little less. These are the amounts of local rain where they first come out into the plains. At 50 miles from the foot of the hills the rivers are receiving from 16 to 24 inches a year of local rain, the smallest amount in the west. A hundred miles farther they are in a belt of country that gets from 10 to 12 inches of rain. And at length, in the region where the rivers all unite, no more than 6 inches of rain fall in the year. And still less further south, in Sind.

The moisture-laden current sweeps over Sind, but no vapour is condensed; air so hot and so unchecked can carry all that water without dropping any. A range of mountains on the coast of Sind would make the monsoon wind yield up some of its moisture before going further, as do the Western Ghâts, not very far off. Mahabaleshwar, 80 miles south of Bombay, has 260 inches of rain in the year to the 5 that fall in Sind. At Mahabaleshwar as much has been known to fall in one day as three times Sind's whole annual supply.

Through this dry country sweeps the mighty Indus, after receiving the contributions of the other rivers. They unite before reaching the Indus, and enter it as one, bearing the name *Panj-nad*, or five streams. It is 50 miles in length from the last confluence, that of the Chenab and the Sutlej. When they meet, the Panj-nad is more than twice the width of the Indus, but its mean depth is much less, and its velocity little more than one-third. Its discharge at the low season is about 69,000 cubic feet per second, that of the Indus 92,000. Below the junction the flood discharge is about 380,000 cubic feet; in exceptional floods much more. One, in the month of August, was estimated at 460,000 cubic feet per second.

All this wealth of water comes from the Indian Ocean, to which

* It was perhaps a personal knowledge of these Himalayan heights that suggested the description given (with a special application to something else) in a recent poem:—

“ an alpine land
Whose lofty peaks look wrapt in cloud and snow ;
But spacious prospects those dim heights command,
And from their seeming-sterile regions flow
The great main springs, whose streams as they expand
Refresh and fertilise the world below.”

Lord LYTON, *Gleaner*.

most of it goes back again. Were the area covered by this ocean land instead of water, we should have a very different state of things and no such Punjab rivers.

When the measure is taken of the water in a river flowing in a wide channel in soft soil, we do not at any time get the whole of it. We measure what is flowing above the bed, but there is more below. It sinks down till retained by some impervious stratum, and may become something like a second river flowing under the large one which we see. It happens sometimes that the whole of a small stream sinks into porous soil and disappears, and if a retentive stratum which it meets below comes out to the surface at a lower part of its course, the filtered water will pour out and become a surface river again, after the ordinary manner of springs. This does happen with some rivers, and it gives some ground for the story about the Saraswati. The experiment has been made on the Jumna of shutting off the whole visible river with a weir and turning it into the canals on either bank. A few miles down, the water trickles down into the bed again, and further down there is a river as before. In most river beds, like those of the Punjab, when they are left dry at the sides in the low season, water is to be got under the dry bed, as well as under the river, and usually at no great depth. Plenty of water can often be got by scooping a mere hole. The water supply of Lahore is pumped from wells sunk in the bed of the Ravi. The water which sinks beneath the beds of these great rivers finds a wide field of hidden usefulness open to it when it gets below. Spreading abroad it meets, and helps to make, the great underground lakes and springs on which every country so largely depends. In the rainless tract around the meeting of the rivers in the south of the Punjab, this underground reserve of water is abundant and near the surface; for the most part it is less than 24 feet below the ground, and in a great part of the country less than 10. In the distribution of these underground reserves of water there are great variations, according to the varying extent, form, and positions of the dividing walls of impermeable soil. The admission of water to new canals is commonly followed by the rise of the water-level in wells within a certain distance on either side. The drying of streams lowers the well-level. In the dry tract south of the Sutlej many wells are over 100 feet deep, some more than 170, with only three feet of water.

The Indus after receiving the other rivers carries down into Sind in the high flood season turbid water containing silt to the amount of $\frac{1}{34}$ part by weight or $\frac{1}{10}$ by volume, equal to 6480 millions of cubic feet in three months of flood, with a discharge of 380,000 cubic feet per second. In the low season, with a discharge of 68,000 cubic feet, the silt is $\frac{1}{533}$ by weight or $\frac{1}{1034}$ by volume. The Ganges often carries even more. The effect of these enormous quantities of silt on the sea-line at the mouths of great rivers, when the deposit of sediment is

undisturbed by coast currents and little affected by tidal scour, is readily understood. The silt is very fine sand and clay. The rapid diminution of slope after the rivers leave the hills, checks the transport of larger matter of any kind. Small rolled stones have been found in the Indus only as far down as five miles below Kalabagh. The stones found in the river near Haidarabad in Sind are local. Part of the silt carried by such rivers is employed in raising the bed of the river itself, where the fall is slight and the flow languid, and then in overflows raising also the banks. Thus the Indus below Sukkur for nearly 400 miles of its course, runs on an embankment made by itself, with a long gentle slope on both sides down to the general low level of the country. While this presents facilities for conveying the water by means of irrigation canals from the river to lands at a distance from it, it also makes the country liable to be flooded by escape or overflow, and increases the difficulty of restraining it when this is required. I was once engaged for a length of time, on a day in the first week of July, in an unequal contest with this big river, which made a breach in a long earthen river-bank that had been hastily thrown up a short time before, to protect a tract of low country from inundation. The utmost efforts of an army of work-people to defend the two ends of the breach and prevent its widening were unavailing with water that had this command of height. It was but a petty side-blow that the Indus was giving, but it was not to be denied.

Mention has been made of certain floods of an unusual character which caused an astonishing rise of the Indus at Attock. One of these floods occurred in 1826, another in 1833, another much larger in 1841. But more is known of the latest, in 1858, when the country was in our hands. In July of that year it was observed at Attock that the river was not rising as fast as usual, and it was seen that there must be an obstruction somewhere, as in 1841. On the 8th of August, the pent-up waters burst their barrier, and rushed down with irresistible fury.* The river rose at Attock, as has been mentioned, to 80 feet above its low-water level. The most striking effect of the flood was this, that the Kabul river, which joins the Indus at right angles above Attock, coming down with a very uniform slope of two feet per mile, was forced back by the Indus flood and driven up stream at a rate of upwards of 10 miles an hour. Meeting the river coming down, it overflowed both banks with great force and inundated the military station of Naoshera, which was almost destroyed. The people first got the alarm—and it was some-

* "Like as a water-streame whose swelling source
Shall drive a mill, within strong bancks is pent,
And long restrayned of his ready course,
So soon as passage is unto him lent,
Breaks forth, and makes his way more violent."

Faerie Queene, book vi. canto 1.

thing to be alarmed by—seeing the river running the wrong way with a velocity greater than its ordinary downward current, but no exertion could avert the damage that followed. Haystacks swept up stream by the Indus, drove against the boat-bridge, and carried it away. Then came the flooding of the cantonment. Some of the larger buildings afforded a precarious refuge on the roof to those who had not fled to higher ground. One of the sufferers described to me how from the top of his house he had looked down on the troubled sea that was swelling around him, and saw his books and furniture washed out at the doors. There were scenes of sad destruction at many places on the banks of the Indus, and very heavy loss of property, though not so much loss of life as in 1841. At Attock the flood continued two days at the maximum height. The obstruction which caused the 1833 flood, according to information received by Mr. Vigne, when travelling among those hills at a later date, was due to the slipping of a glacier on the upper course of the Shayók river (the chief hill tributary, which joins the Indus after a course of 350 miles). The others were similar in their cause, at different places. The late Mr. Hayward, on his explorations in Gilgit in 1870, mentions a temporary obstruction of this kind forming a lake in the Gilgit Valley, in which valley also he believed the flood of 1858 to have originated. It has been attributed, with more probability, to a landslip near the sharp southward bend of the Indus, 70 miles below Iskardo. A flood of similar kind is said to have occurred on the Sutlej in 1762.

It will readily be supposed that a land intersected as the Punjab is by great rivers which flow in one united stream to the ocean, that is, which has a great water highway *from* the sea, sending out branches that divide the land among them, is eminently provided with means of water communication. The map would seem to say so. But when we know the characters and habits of the rivers, we readily understand that the facilities for navigation are not quite what they seem. Great hopes have been entertained at various times of a large steamer traffic on the Punjab rivers. It was one of the purposes of sending Lieut. Burnes by water to Lahore in 1831 with the presents for Ranjit Singh, to see what could be made of river traffic with the Punjab. In 1835 the first steamer was seen on the Indus. A small steamer passed up that river once as far as Attock. Steamers have ascended the Sutlej to a little above Firózpúr, the Jhelum to Pind Dadan Khan, and the other rivers shorter distances. A regular steamer service was maintained for some time on the Indus up to Mokhad, 25 miles above Kalabagh. But to all these attempts at steam navigation, above 600 miles from the sea, the obstacles presented by the shifting nature of the streams and shoals involved expenditure of time and money not warranted by the traffic return. Steam navigation of these rivers is now practically confined to the part from Tatta at the head of the delta up to Multan. No doubt much

could be done by means of river works to keep open some permanent navigable channels. But river conservancy in this sense was too costly a business to be adopted throughout. It is found better where steam navigation is kept up, to maintain a system of local pilotage. Though these rivers are not well fitted for steamers, even of very light draught, there is a large amount of boat traffic, and a brisk trade in boat-building at places near the foot of the hills where the timber brought down by the rivers from the deodar forests is received. There are at present between 5000 and 6000 boats of large size, constantly employed on the several rivers. From April to September the wind is from the south, favouring upward traffic. For the rest of the year it blows in the opposite direction. A long time ago, before the days of steamers, and when not much was known about the rivers, there were English people who looked somewhat vaguely for great things on these unexplored highways. A gentleman who joined the East India Company in May 1609, wrote four years later that there were "many far-fetched projects on foot how to draw all the traffic of Persia and the inland parts of the East Indies up the river Hydaspes (Jhylum) into the Oxus, that falls into the Caspian Sea," thence "to be brought up the Volga."

Without being inclined to revive the project in this form, with the modern advantage of steam power, we may yet desire to see something done for the furtherance of steam navigation on the Punjab rivers. They are nature's gift, of no small value—it is for us to see what we can make of them. Though the hindrances are considerable they are to be overcome if there is sufficient motive. The rivers, though on the whole very unmanageable, can yet to some extent be managed and turned to account. On the one hand we find it needful to protect the land against the water, on the other we find it useful to draw the water on the land. Few things can be of higher importance to a hot and dry country than the wise use of available surface water. Artificial irrigation supplies the wants of ill-favoured times and ill-favoured places. If it is one of its most important purposes to secure in bad times (that is, on failure of the periodical rains) the products of land abundantly fertile in ordinary seasons, so as to have at all times, on certain areas of country, harvests that can be depended on, it is likewise its purpose to lead these surface streams to "fresh fields and pastures new"; to plant verdure in the desert; to make possible the production on new ground of the kindly fruits of the earth; to send out refreshing streams and furnish supplies of water for man and beast; to make more abundant and more accessible the water to be obtained from the ground; to repair the damage done in past time by ignorant, perverse, or short-sighted men, and help to restore the wealth of wood that once sheltered and enriched the soil; by this means also to draw down in more abundant measure the bounty of nature from the skies, to nourish and to reproduce what has been raised. This is something we can do to make changes for the better in the face of the

land, if the rivers of themselves are sometimes apt to make changes for the worse. As they make their way across the broad low plains of India, which they have helped to make, they let us see the wealth of their resources for good or evil. Controlled and guided, led and regulated, they serve to show instructively the power of man's influence on the physical as well as the political geography of a country.

Notes on the Physiography of Southern India.

By Col. B. R. BRANFILL, late Deputy-Superintendent, Survey of India.

(Read to the Geographical Section of the British Association at Aberdeen,
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THE part of India on which I have been invited to offer some notes, culled from the recollection of many years' service passed there, lies to the south of lat. 15°. It is the apex of the Peninsula, and coincides nearly with the Madras Presidency of British India. It is a beautiful country, displaying a charming variety of surface and scenery. Its climate, though tropical, is mild and generally agreeable, being almost insular, and subject to the breezy influences of the two monsoons. It is an epitome of all India, in its lofty hills and extensive plains, its flooding rivers and dwindling lakes, its fertile flats and sterile wastes, its tropical jungles and its scrubby wilderness.

Southern India is an interesting field of observation for the scientific inquirer, and especially for the physiographer, on account of the elements of physical change it displays in ceaseless activity. For, we have first, the decomposing and disintegrating power of the sun's rays, vertical here twice in the year; secondly, we have the long continued strong winds, that scour the surface and transport immense volumes of dust to great distances in the air, and, by means of the waves, along the sea-shore; and thirdly, the dissolving and denuding force of a tropical rainfall.

Frost is only known upon the high plateaux and mountains, and the violent earthquake is almost unknown, but the agencies just mentioned seem fully adequate, in process of time, to convert a vast plateau of igneous rock into the subdued and diversified area we now behold.

For our present purpose, Southern India may be divided into three tracts or regions. Firstly, the mountainous region of the Ghâts, including the higher tablelands, and the great upland plains of Mysore, contained between the brows of the Western and Eastern Ghâts. Secondly, the lowlands of the Malabar coast, all that narrow tract of moist seaboard between the foot of the Western Ghâts and the Arabian Sea; and, thirdly, the comparatively wide and dry lowland plains of the Carnatic, between the eastern foot of the Ghâts and the Bay of Bengal.

The first is the highland tract, wide in the north, but tapering to a